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## SOME PRACTICAL SUGGESTIONS ON THE EQUIPMENT OF A PSYCHOLOGICAL LABORATORY.

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The kind of equipment a psychological laboratory is to have should be controlled by the needs of the students that are to use it, the amount of money at command, and the special lines of interest of the instructor in charge. To give detailed advice without detailed information on these points is impossible. It is hoped, however, that a few general suggestions with regard to rooms, apparatus and method of instruction, though without novelty to those already in possession of laboratories, may not come amiss to those having them in contemplation.

### ROOMS.

This important part of the laboratory is unfortunately too often not under the control of those most interested. The laboratory must occupy such rooms as are free for it. As a younger member in the family of sciences, psychology must be content with the outgrown clothes of its elders. If any choice is possible several points should be regarded, and first of all, quiet. It is relatively easy to shield the eyes and skin from intrusive stimulation, but it is extremely difficult to shield the ears; and what freedom from jar is to the physicist, that freedom from noise is to the experimental psychologist. Heating, lighting and ventilation are important in all study rooms, and *a fortiori* in rooms where bodily conditions must

be kept constant and prevented as far as possible from disturbing mental conditions.

As to size, a number of small rooms are better than an equal floor space thrown into one or two large rooms, for there are not many psychological experiments that can be made simultaneously in the same room without mutual interference, and for the few that require considerable distances, it is better to depend on a spare lecture room or chapel. The most convenient arrangement is one large room for a general laboratory and apparatus room, and several small ones that can be used, though not exclusively, for special purposes : one for the instructor's private laboratory, one for light and color experiments, one for time experiments, a storeroom for bulky apparatus, and especially one for a work-shop, though this need not be adjacent to the rest. It is also convenient to have a small room or closet, suitably connected by wire with the other rooms, in which all batteries may be kept and cared for. There is a temptation to use the large laboratory room as a lecture room also, but this should be resisted on account of the dust from the blackboard.

The situation of the rooms is relatively unimportant, except in the case of rooms where light and color experiments are to be made, which should have a southerly exposure, so that direct sunlight may be had. Proximity to highly colored buildings or green trees is to be considered, and there should be no tinting on the walls. Rooms in an upper story of a large building have an advantage both as to light and stillness.<sup>1</sup>

If it is inexpedient to devote a room exclusively to light and color, *i. e.*, to make a dark room of it, much can be done with dark boxes of convenient size ; or, following the plan of the Yale laboratory, the dark box may be enlarged till it will take in the experimenter himself and becomes a room within a room. Such an arrangement has much to recommend it.

#### FURNITURE.

All the rooms should have gas or electric lights for illumination ; the general laboratory and the work-shop should have gas for heating ; and the first should have a sink and water. The general laboratory and the dark room should be provided with means for excluding light. For the first, where only a relative darkening is needed, black curtains or curtains of enameled cloth will answer, but an extra casing must be fastened to the window frame, covering the edges of

<sup>1</sup>See plan of the Toronto laboratory where these points are regarded, *Science*, XIX, 1892, 143.

the curtains and preventing the light from getting in beside them. The curtains must pull up from the bottom, not down from the top. More pains will have to be taken with the dark room, and there solid shutters of some kind, painted black like the walls of the room, will probably be as satisfactory as anything.<sup>1</sup>

Tables for laboratory use should not be so good as to be marred by an occasional tack driven into them. Some should be large (3x8 ft. or longer) and some small (2x4 ft.). If some are thirty-six inches high (for use when the experimenter stands), and others are six inches less (for use when he is seated), it will be well; and it will not be amiss if all are provided with drawers. It is convenient to have one or two very solid tables with square legs the same size at the top and the bottom, so that apparatus may be clamped to them. There should also be a few small tables that are adjustable in height. They are almost indispensable when several irregular pieces of apparatus are to be brought to the same level for combined use. Such tables with iron standards can be bought, or they may be made wholly of wood by any carpenter. A wedge to hold the table at the required height is better than a screw, for it does not mar the stem of the table and is more effective against wobbling. Three sizes at least are handy: a small size to stand on the ordinary tables and capable of adjustment from twelve inches to eighteen inches in height; a larger size capable of adjustment from twenty-four to thirty-six inches; and a third size adjustable from four to six feet. For a purpose similar to that of these tables the laboratory should have a good supply of smooth blocks, six or eight inches square and from one to two inches thick; also a few smooth bricks, which may be permanently covered with thick paper for greater cleanliness in use.

A shelf running along the side of the room and before the windows at about the height of the ordinary tables, is very convenient. If it seems undesirable to fasten such a shelf permanently, narrow tables or benches may well take its place. Chairs for the laboratory may be of any comfortable sort; physical discomfort is a serious hindrance to successful work for both the subject and the operator. There must be also a few screw stools, so that the height of the observer with reference to his instrument may be readily adjusted.

The number and character of the apparatus cases will be fixed by the apparatus to be placed in them, but they should be large enough to prevent crowding and some of them at

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<sup>1</sup> Aubert gives some particulars about the construction of a dark room in his *Physiologie der Netzhaut*, pp. 26 ff.

least should be closed with hinged glass doors ; sliding doors are apt to strike and break apparatus carelessly put in.

Either below the apparatus cases or in a case by themselves, the laboratory must have a plentiful supply of drawers, and some of these should be divided by low partitions for the more easy keeping of such things as kymograph papers, small diagrams for optical experiments, etc. Drawers that are to contain many kinds of things, as, for example, the drawer for nails, screws and tacks, may conveniently be fitted with a number of little compartmented trays instead of fixed partitions. The trays can then be taken out and carried about with their contents as needed and again returned to their place in the drawer. Some of the drawers should be large enough to allow full sheets of cardboard to lie flat in them, unless they can be kept in a chart case.

In the matter of chart cases there is great diversity of practice. A convenient way where one has control of the making of his charts is to have them all drawn upon uniform sheets of manilla or other cardboard (using several separate sheets for large diagrams), and then have a case of shallow drawers in which to keep them. These drawers should have backs and sides, but no fronts, or fronts that are hinged and can be turned forward out of the way. In such a case the charts are kept flat and the edges of all can be easily examined without disturbing any. The front of the case can be protected by doors or a curtain.

Many colored papers fade if long exposed to the light and must be protected from it. A convenient way to do this with disks already cut for use on the color-mixer, and yet to have them easy of access, is to prepare a special case for them. A piece of pine plank two inches thick, somewhat wider and four or five inches longer than the diameter of the disks, has near one end a circular hole cut through it just large enough to take in the disks. From the side of this hole next the longer end, a slot an inch and half wide is cut nearly or quite to the end. A thin piece of board of the same size as the plank is nailed on for a bottom ; a similar piece is hinged on the top for a lid, and a narrow piece nailed across the end of the slot, if it has been cut entirely through, and the case is complete. When the colored disks are laid in, the different colors are kept separate by disks of ordinary cardboard. These have tongues that lie in the above mentioned slot (the longest ones at the bottom), each bearing the name of the color that has been put in below it. Any required color can then be found at once by lifting the tongue bearing its name.

In the general laboratory there should be a bookshelf containing the textbooks most frequently consulted, including a stand-

ard text-book of physics and a book of mathematical tables. And near by may well be kept a card catalogue of psychological literature. Such a bibliography, if contributed to from the reading of all users of the laboratory, would soon grow into a most valuable aid to research. In the cabinet may also be kept a card catalogue of the apparatus, giving the name of the maker, date of receipt and price of each piece, and in addition any constants or corrections that it may be necessary to know for the accurate use of the piece in question. This list will be found useful, not only in checking up apparatus at times of stock-taking, but also in giving students items about the manufacture of the apparatus that they may be interested to know.

#### APPARATUS.

If a carpenter and skilled machinist are at command, comparatively few pieces of apparatus will need to be bought outright, and much of the rest will be cheaper made at home. Even when such help is not forthcoming, the instructor himself, if moderately familiar with the rudiments of wood and metal work, can do a good deal. A certain knowledge of these arts is important, even for the successful use of boughten apparatus, and every instructor should take pains to acquire it. Such hand work will often be found an agreeable change from book work.

Assuming that the instructor has a little mechanical skill, and that professional mechanics will only be appealed to in cases of especial difficulty, the first room of the laboratory to be fitted up may well be the work shop. Here should be found a small bench with both carpenter's and machinist's vises, and the most common tools for wood and metal work. A lathe also should certainly be added, with a sufficient stock of chucks and lathe tools, though an excessively high-priced machine is not necessary. A hundred dollars expended upon tools of all sorts and fifty dollars more upon the fitting up of the room and the purchase of materials, would probably be sufficient, and would soon save its value in the making and repair of the strictly psychological equipment. If nothing of this sort is possible, a few tools at any rate are indispensable; large and small screw-drivers, a wrench, a hammer, with nails and tacks, a meter stick, and an oil-can are perhaps the minimum collection.

The strictly psychological apparatus to be purchased will vary with the plan of work and with the facilities for borrowing from the physical and biological departments. If, as is probably the case in most American colleges, demonstrations

are to be made before a class of twenty or upward, a practice laboratory course given to a less number, and research to be carried on by the instructor and one or two advanced students, and if the department is expected to stand on its own feet without much borrowing, the stock of apparatus may be somewhat as follows:

*Apparatus for neurological demonstrations.* Models of the brain<sup>1</sup> and sense organs; microscopes and mounted specimens; frogs; sheep's brains and facilities for removing and preserving them;<sup>2</sup> reagents; diagrams; to a total of about three hundred and fifty dollars.

*Apparatus for the senses.*<sup>3</sup> Since a good part of the work so far accomplished in physiological psychology has been upon sensation and perception, this section of apparatus will naturally be pretty full, especially as many pieces are also of use for the study of the higher forms of mental life. For the senses of taste and smell a very small expenditure is sufficient. For the dermal senses and sensations of motion the apparatus, except for advanced research, is simple, and much of it can be made by any carpenter. An allowance of one hundred and fifty dollars should cover everything. For auditory experiments more refined apparatus is required. It would be easy here to spend two hundred and fifty dollars without exceeding the bounds of economy. Apparatus for vision and the visual perception of space, including in this a good supply of stereoscopic and other diagrams, would require perhaps three hundred dollars. Some allowance should also be made for apparatus for the study of pain, a promising subject as yet little investigated, making a total for all the senses of something over seven hundred dollars.

*Time apparatus.* A very successful means of study of the higher mental functions has been the measuring of their time relations. The standard instrument for this is the Hipp chronoscope, which itself costs about seventy dollars, and requires for full usefulness batteries, testing apparatus, electric keys, commutators, etc., to the amount of perhaps a hundred dollars more. Of almost equal importance and of more varied usefulness is the Ludwig kymograph, an apparatus for furnishing uniform motion, either to the drum that forms part of the apparatus itself, or, as a motor, to other light pieces

<sup>1</sup> See Notes on Models of the Brain, by H. H. Donaldson, AMER. JOUR. PSYCHOL. IV. 130.

<sup>2</sup> See chapter on the Structure of the Brain in James's briefer course on Psychology.

<sup>3</sup> For detailed suggestion as to apparatus for the senses, I may refer to the introductions to the successive sections of my laboratory course in earlier numbers of this JOURNAL.

of apparatus. The instrument is delicate, and is expensive (it costs about two hundred dollars), but in very many lines of work its absence is a great loss. There are, however, a number of cheaper substitutes for it which could probably be made to answer most purposes, and even if a kymograph is included, it will be best to include also some simpler form of rotating drum to use when regularity of motion is not required. As in the case of the chronoscope, a good deal of accessory apparatus is required to get the full advantage of this central piece; there should be two or more electrical time-markers, an electrically excited vibrator and a tuning fork of 100 v. d. per sec., Marey tambours, etc., etc., with conveniences for smoking the paper-covered drums and fixing the tracings when made. For the chronoscope and kymograph and their appurtenances, an allowance of at least five hundred dollars should be made.

The *psychophysi*c law may be studied with apparatus already included under the foregoing heads, but some new pieces or adaptations of those already mentioned are useful, and for them seventy-five dollars may be set aside.

*General apparatus.* In addition to the apparatus for more or less specific uses there is a class of general apparatus that is no less important; and chief among this class is a good-sized and substantial collection of stands, rods and clamps. Money spent on these will be well invested, as the later saving of time and exasperation will demonstrate.<sup>1</sup> There should also be included a number of black, white and gray screens that may be made to fit the rods and stands. A plethysmograph and sphygmograph should be in the collection. There should be some kind of a motor in the laboratory more powerful than the kymograph, electric or water, as convenient. A good set of drawing instruments, with brushes and colors, will find frequent use; also a number of beakers and flasks, several graduates and a pair of scales with weights. There should be a clock, towels, wastebaskets and slop jars, dustpan and brush, several china plates, cloth for covering apparatus outside of the cases when not in use, and a good deal of other miscellaneous stuff, which, with the rods and clamps and the rest, may consume as much as two hundred dollars. In the laboratory should also be found a moderate stock of cardboard (black and white), colored papers, pins, needles and thread, mucilage, glass tubes and rods, alcohol, mercury, shellac varnish, sealing-wax, corks (rubber and ordinary), rubber tubing and sheets, hard rubber, shot, sheet lead, cotton batting, etc., etc., which might be covered by twenty-five or thirty dollars.

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<sup>1</sup> On apparatus of this sort see AMER. JOUR. PSY. V. 476, 499.

The total cost of apparatus on the scale indicated, without allowing for the duplication that might be needed for large classes, is thus something above two thousand dollars, but no allowance has been made for transportation of imported apparatus (a large item), nor for such special pieces as would be desired for special original researches, nor yet for the fitting and furnishing the rooms. It is not an overestimate to say that a fully-equipped laboratory in an institution of college grade may be expected to cost between four and five thousand dollars. A sum from one hundred to two hundred and fifty dollars a year would be needed for supplies, repairs and the purchase of new apparatus, and these figures would have to be still larger if many students were engaged in research.

A beginning, however, can be made with a good deal less than five thousand dollars. In the hands of a mechanically skillful instructor a tenth of that sum spent upon tools and cardinal pieces of apparatus, though wasteful of the instructor's time, would give a very fair start, and even two hundred and fifty dollars spent on apparatus alone would do much to enliven and fructify the course in psychology. If a starvation appropriation is all that is to be had, the most satisfactory pieces would probably be: a sonometer and a few tuning-forks for audition, a color-mixer and Wheatstone stereoscope for vision (the latter home made), and a stop watch for time measurements.

#### ON THE USE OF THE LABORATORY.

Psychological experiments fall roughly into three classes : first, those that can easily be made by a large number of persons at once, as some experiments on hearing and vision, and also some on association and attention ; second, those that can be made quickly and easily, but by only one person at a time without duplication of apparatus, including many experiments on touch, subjective visual and auditory phenomena, and binocular vision ; and third, experiments that require a considerable time, including all the quantitative experiments, reaction-times, memory and memory span, psycho-physic law, etc., where the average of a number of individual tests is necessary to give a sure result. This difference will of course be recognized in planning the work of the department. It would be a great blunder to rob the lecture course of its illustrative experiments to crowd them into the laboratory. Experiments of the second class may well go into a demonstration hour in the general laboratory room following the lecture, when, without formality, apparatus may be passed from hand to hand and questions asked and explanations

given. To these also should be added some of the experiments of the third class, given in a demonstrational way, for the sake of students who do not follow the subject further. The third class of experiments in their rigor should be reserved for attack at another hour with those who wish serious laboratory work.

Most teachers, I believe, will find it difficult, at least in the present state of experimental psychological courses, to keep more than six or eight students profitably busy at the same time, especially at first, when some may have a merely spectacular interest in the subject. Larger numbers must be handled in sections.

In many psychological experiments it is necessary that two persons work together, one as subject and one as operator, and for this purpose a selection of partners for the course at the beginning is to be recommended. The order in which work is taken up in the laboratory is not of extreme importance, and if the apparatus contains no duplicates, as many lines of work must be started at once as there are partnerships of students. The following half dozen lines of work will illustrate what I mean, though every instructor will probably prefer to frame his own : 1. The senses, experiments not included in the lecture and demonstrational courses. 2. Reflex action and selected nerve-muscle experiments. 3. Reaction-times and related experiments. 4. Memory span for sounds, letters and numbers, and with distracted attention. Card sorting test for memory as described by Bergström in the last number of this JOURNAL, and possibly some adaptation of a few of Ebbinghaus's experiments with nonsense syllables. 5. Attention and its motor accompaniments, inversion of time order of sensations, as shown in Exner's and Dvorák's experiments. 6. Weber's law, with detailed work on some one method, with full demonstrations of the others.

In the prosecution of these and all other experiments, the art of the teacher will appear in leading the students to observe for themselves and to draw their own inferences. They should at the same time be shown how to keep intelligible records of their work. Indeed all the pedagogical principles already established for laboratory physics, chemistry and biology apply with equal force here, and very much of primary importance may be learned from experienced teachers of these subjects, both with reference to the furnishing of the laboratory and the handling of the pupils in it.

After so much of a general orientation as would be given by work in several of these lines, the student may enter upon original work as an apprentice to the instructor, serving alternately as subject and operator, and being

encouraged to contribute in every way to the success of the research and to feel a part of the responsibility for its scientific character.

At some place in the course, room should be found for the gathering among the class or the college at large of statistics of colored-hearing, number forms, lists of associated words, etc., not only as a means of interesting the pupils, but also as a means of giving them, in the proper working up of the figures, some training in the handling of statistics and some insight into the large fields of observational psychology in which the statistical method seems at present our chief resource.<sup>1</sup> To this, if opportunity offers, may well be added the observation of the behavior of certain lower forms of life and of the domestic animals, especially when young, and of children.

It is hardly necessary to say in conclusion that any one having the equipment of a laboratory in mind should not fail, even at some expense of time and money, to visit as many as possible of the existing laboratories and learn by direct inspection and conversation what his colleagues have found desirable and what is to be avoided.

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<sup>1</sup> For accounts of such studies, though executed by instructors instead of pupils, see Jastrow, *Educational Review*, II. 1891, 442-452; Patrick, *Popular Science Monthly*, Feb., 1893; and the paper of Mary Whiton Calkins in this number of the JOURNAL OF PSYCHOLOGY.